

# Geant 4

*Starting with an example*

<http://geant4.cern.ch>

# PART I

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Set your  
environment up and  
get a Geant4  
example

# Getting started

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First, you have to **access the common PC** where Geant4 is installed, and set the environment variables up:

- from your laptop, open a **ssh connection** to the IP address **141.25.68.196** (be sure to have your **X-server on**, e.g. by Xming, to open graphic windows). *UserID and password are given to each student.*
- since the script for setting the environment up works for **tc-shell**, give the command **tcsh**
- run the script to set the system up:

```
source /course/env.sh
```

# Set environment variables (1)

## Libraries and system settings

```
setenv G4SYSTEM Linux-g++
setenv G4INSTALL ../../geant4/geant4.9.1
setenv G4INCLUDE $G4WORKDIR/include
setenv G4LIB $G4INSTALL/lib/
```

} Geant4 installation info

```
setenv G4WORKDIR $HOME
```

} User's working directory (libs and bins)

```
setenv CLHEP_BASE_DIR ../../CLHEP/../../2.0.x.x
```

```
setenv LD_LIBRARY_PATH
"$CLHEP_BASE_DIR/lib:$LD_LIBRARY_PATH"
```

CLHEP installation directory and libraries

# Set environment variables (2)

## Geant4 databases

`setenv G4LEVELGAMMADATA /.../PhotonEvaporation`

→ Directory with the DB of [Nuclear Levels](#)

`setenv G4RADIOACTIVEDATA /.../RadioactiveDecay3.2`

→ Directory with the DB of [Radioactive Decay](#)

`setenv G4LEDATA /.../G4EMLOW5.1`

→ Directory with the DB of [LowEnergy EM physics](#)

`setenv G4NEUTRONHPDATA /.../G4NDL3.12`

→ Directory with the DB for [low-energy neutrons](#) (cross sections and final states), from thermal to [20 MeV](#)

`setenv G4ELASTICDATA /.../G4ELASTIC1.1`

→ Directory with the DB for [hadron elastic scattering](#)

`setenv G4ABLADATA /.../G4ABLA3.0`

→ Directory with the DB for [Ablation hadronic models](#)

# Get an example to run (1)

A number of ready-for-the-use **examples** are **released** with the **Geant4 code**

```
cd $G4INSTALL/examples
```

Three classes of examples:

- **novice**: show **basic functionalities** of Geant4
- **extended**: show in more details **specific functionality** of Geant4 (e.g. biasing, electromagnetic or optical physics, magnetic fields, ...)
- **advanced**: **full simulation** of a **realistic** experimental **use case** (medical physics, underground physics, calorimetry, ...)

## Get an example to run (2)

Let's try a **novice example** (N03). Copy the source code **in your working directory**

```
cd $G4INSTALL/examples/novice  
cp -r N03 $G4WORKDIR
```

What's **N03** about?

Read the file called **README** in the **N03** directory for basic information: "**This example simulates a simple Sampling Calorimeter setup**".

A **more detailed** description of the functionalities is also included in the **README**

# Compile the example

Now, compile the example and get an executable to run

```
cd $G4WORKDIR/N03  
  
gmake
```

```
Making dependency for file exampleN03.cc ...  
Making dependency for file src/ExN03SteppingVerbose.cc ...  
[...]  
Compiling ExN03DetectorConstruction.cc ...  
Compiling ExN03DetectorMessenger.cc ...  
Compiling ExN03EventAction.cc ...  
[...]  
Creating/replacing object files in /exampleN03/libexampleN03.a ...  
Compiling exampleN03.cc ...  
Using granular libraries ...  
Linking exampleN03 ...  
... Done!
```



# Eventually, the executable

---

When compilation and linking are successfully completed, you get an **executable file** to be **run**

```
$G4WORKDIR/bin/Linux-g++/exampleN03
```

**Warning**: to run the executable your **environment variables must be set**: **shared libraries** are used. Furthermore, the program needs the environment variables pointing to the **Geant4 databases** (if they are not found, the program **might crash**)

## PART II

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Run the Geant4  
example

# Run without macros (1)

No argument given after the executable name:

```
$G4WORKDIR/bin/Linux-g++/exampleN03
```

```
*****
Geant4 version Name: geant4-09-01-patch-01    (25-January-2008)
                    Copyright : Geant4 Collaboration
                    Reference  : NIM A 506 (2003), 250-303
                    WWW      : http://cern.ch/geant4
*****

**** Table : Nb of materials = 13 ****
[...]
-----
---> The calorimeter is 10 layers of: [ 10mm of Lead + 5mm of liquidArgon ]
-----

[...]
You have successfully registered the following graphics systems.
Current available graphics systems are:
  ASCIIITree (ATree)
[...]
Idle>
```

# Run without macros (2)

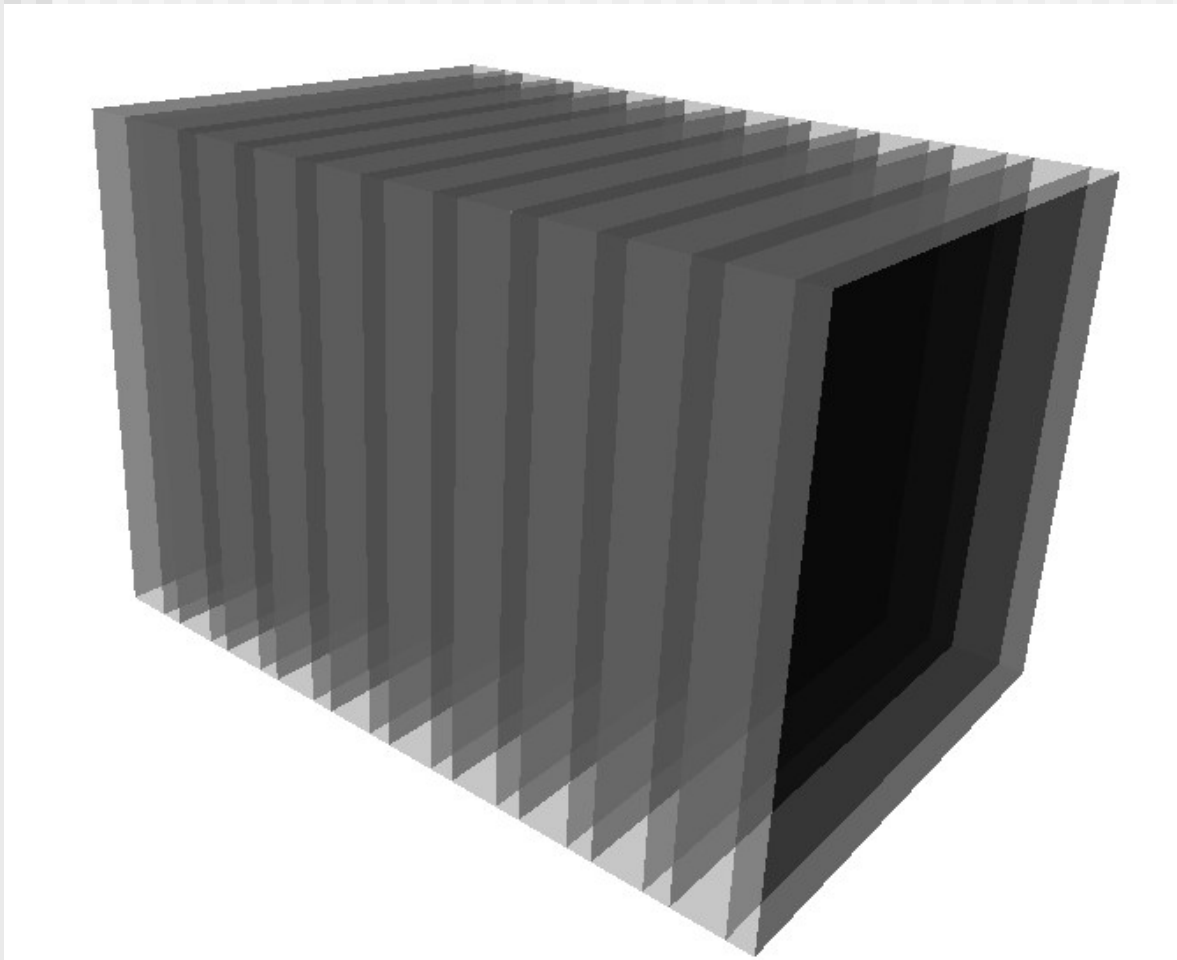
---

What did it happen?

- 1) the `run` is **initialized** (define materials, build geometry, set physics and production cuts, ...)
- 2) the macro `vis.mac` is **automatically executed** to register the visualization drivers (default: OGLIX), the **set-up is shown** on a graphic window (OpenGL)
- 3) eventually you get the **Idle> prompt** where you can give **commands interactively**
  - e.g. change geometry, decide which particle to shoot, which energy, execute an other macro, shoot a particle, ..

# The default geometry

---



Visualization of the setup using the [VRML2FILE](#) driver

Default geometry:

10 layers, 10 mm Lead + 5 mm Liquid Argon, no magnetic field

# Run without macros (3)

Let's try to shoot a particle:

```
Idle> /run/beamOn 1
```

By default it is a 50 MeV  $e^-$  impinging perpendicularly on the calorimeter

```
phot: Total cross sections from Sandia parametrisation.  
Sampling according PhotoElectric model  
[...]
```

Initialization  
of physics  
tables

```
===== Table of registered couples =====  
Index : 1 used in the geometry : Yes recalculation needed : No  
Material : Lead  
cuts : gamma 1 mm e- 1 mm e+ 1 mm  
Energy thresholds : gamma 100.5 keV e- 1.37 MeV e+ 1.28 MeV  
Region(s) which use this couple : DefaultRegionForTheWorld
```

Calculation  
of energy  
cuts

# Run without macros (4)

---

-----  
---> End of event: 0

**Absorber: total energy: 48.485177 MeV**

total track length: 3.4402456 cm

**Gap: total energy: 101.79095 keV**

total track length: 151.87063 um

=====

[...]

-----End of Run-----

**mean Energy in Absorber : 48.485177 MeV +- 0 eV**

**mean Energy in Gap : 101.79095 keV +- 0 eV**

mean trackLength in Absorber : 3.4402456 cm +- 0 fm

mean trackLength in Gap : 151.87063 um +- 1275.93 fm

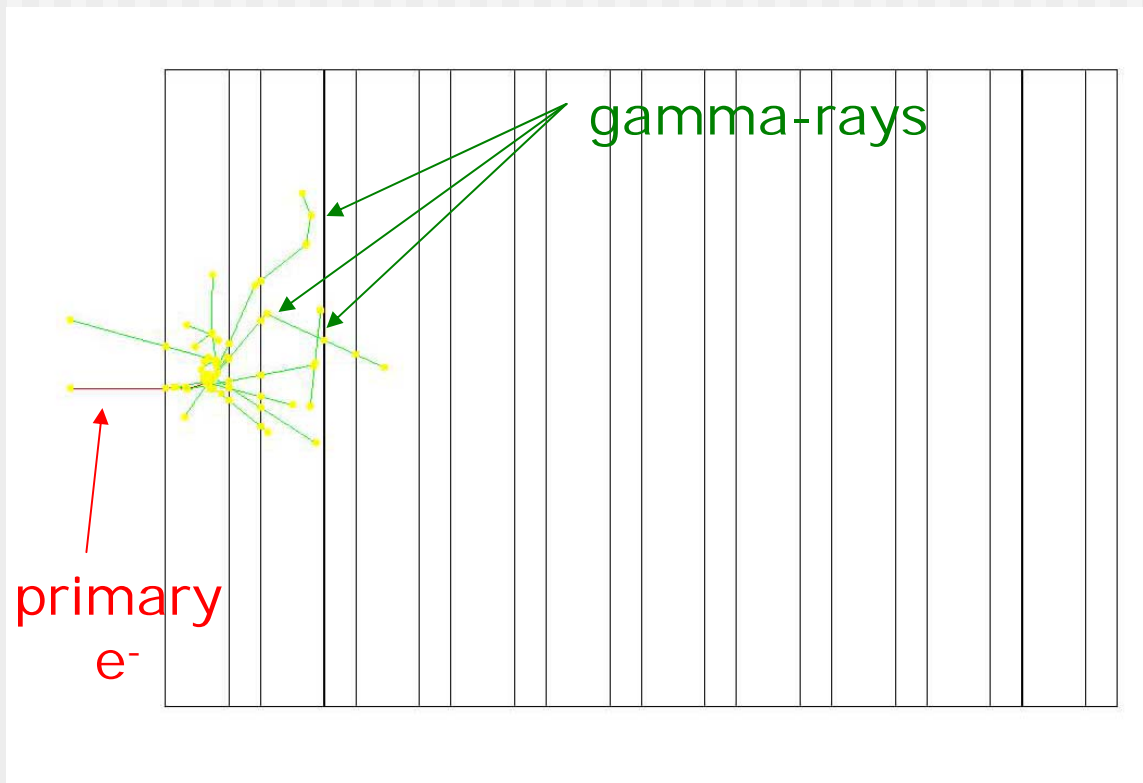
-----

Event  
summary

Run  
summary

# Run without macros (5)

You also get a **visualization** of the **event** you have just shot (50 MeV  $e^-$ )



DAWNFILE  
visualization  
driver

Default color code:

red = negative  
charged

blue = positive  
charged

green = neutral



# Run with a macro (1)

The argument following the executable name is taken as a **macro name**

```
$G4WORKDIR/bin/Linux-g++/exampleN03 run1.mac
```

Geant4 macros are **ASCII files** containing a **sequence of Geant4 commands**:

```
#  
/run/verbose 2  
/event/verbose 0  
/tracking/verbose 1  
#  
/gun/particle mu+  
/gun/energy 300 MeV  
/run/beamOn 3
```

} Shoot 3  $\mu^+$  of energy 300 MeV

# Run with a macro (2)

---

---> End of event: 2

Absorber: total energy: 132.1342 MeV

total track length: 10.991574 cm

Gap: total energy: 10.196106 MeV

total track length: 5.237927 cm

Summary of  
event #2 (the  
3<sup>rd</sup> one!)

Summary of  
the full run

-----End of Run-----

**mean Energy in Absorber** : 131.72328 MeV +- 566.41301 keV

**mean Energy in Gap** : 10.815019 MeV +- 632.91131 keV

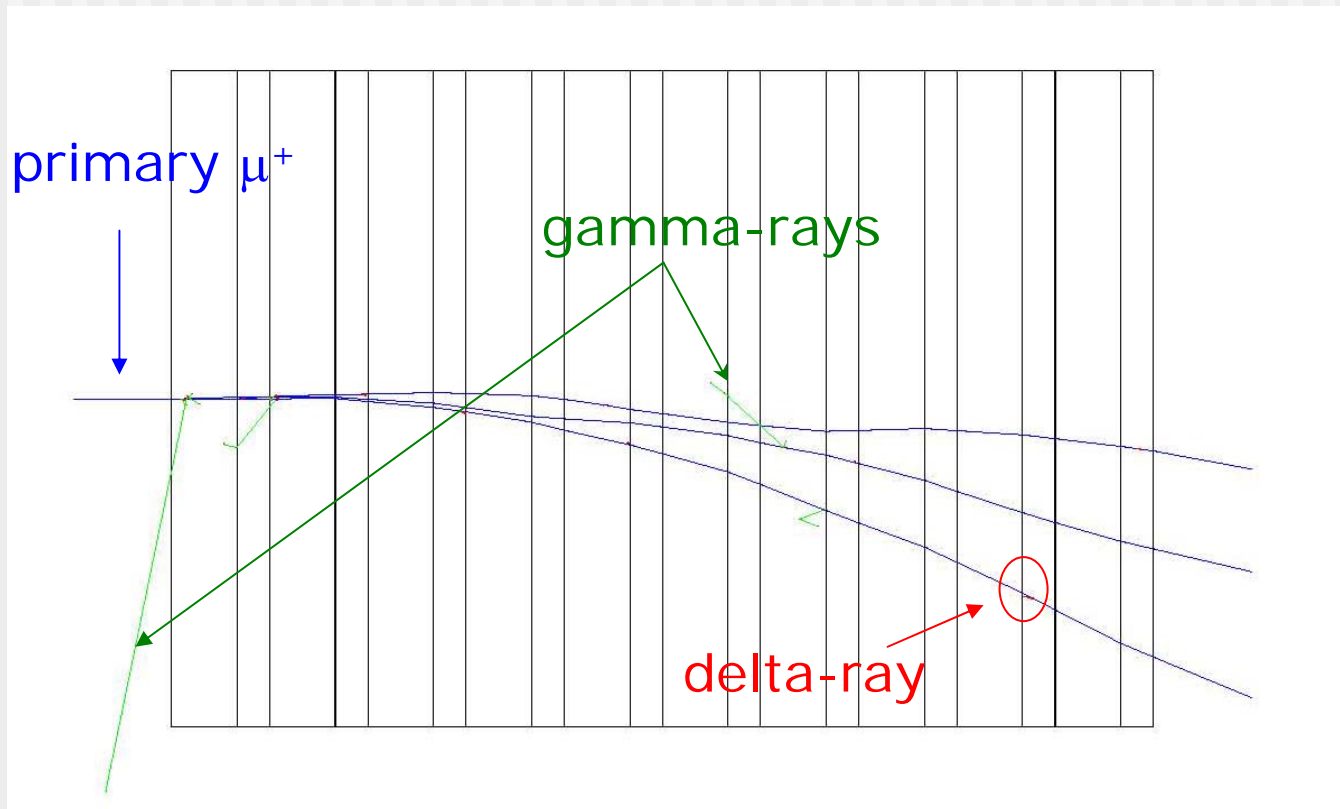
mean trackLength in Absorber : 10.851375 cm +- 992.81395 um

mean trackLength in Gap : 5.5269735 cm +- 2.9028931 mm

-----

# Run with a macro (3)

Screenshot of the 3 events:



# Run with a macro (4)

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Notice:

```
$G4WORKDIR/bin/Linux-g++/exampleN03 run1.mac
```

is equivalent to

```
$G4WORKDIR/bin/Linux-g++/exampleN03
```

```
[...]
```

```
Idle> /control/execute run1.mac
```



command to run an external macro

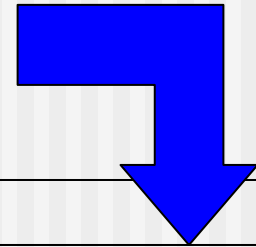
(but in the second case you get the Idle> prompt back)

# Change geometry on-the-fly (1)

```
$G4WORKDIR/bin/Linux-g++/exampleN03
```

```
Idle> /control/execute newgeom.mac
```

```
Idle> /control/execute run1.mac
```



First macro changes geometry:

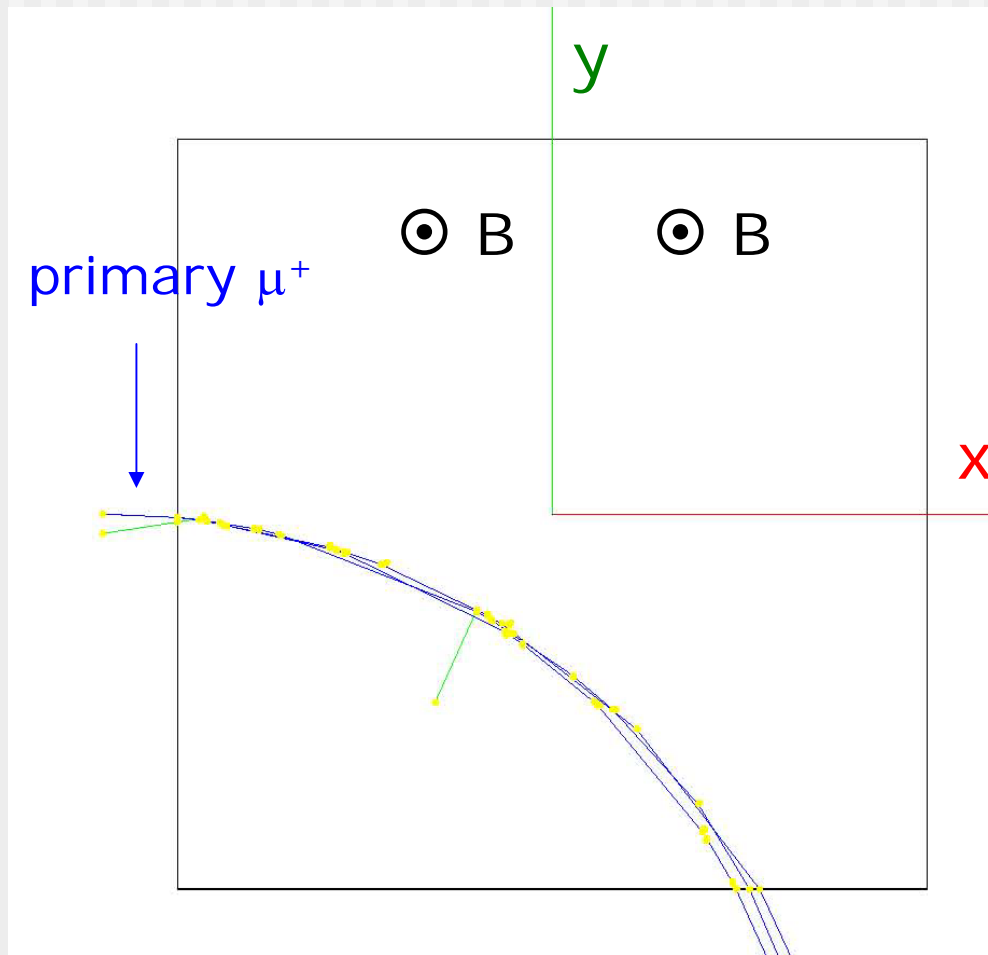
only **one layer** of absorber (**40 cm of water**), **no gap** (thickness = 0 cm) → practically a **solid block of water**

Change **transverse dimensions**, set a **3 T magnetic field**

```
/N03/det/setNbOfLayers 1  
/N03/det/setAbsMat Water  
/N03/det/setAbsThick 40 cm  
/N03/det/setGapMat Air  
/N03/det/setGapThick 0 cm  
/N03/det/setSizeYZ 40 cm  
/N03/det/setField 3 tesla  
/N03/det/update
```

The second macro shoots the 3 300-MeV  $\mu^+$ , as before

# Change geometry on-the-fly (2)



Geometry, materials, magnetic field and primary particles can be tuned by ASCII macros, without need to recompile the code

# PART III

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## Summary

# Summary

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- Geant4 provides **several examples** to **show** basic and advanced **functionalities** (novice/extended) and full-scale **realistic applications** (advanced)
- **Environmental variables** should be properly set to compile and run Geant4 applications
- Geant4 applications can be run **interactively** (namely, giving commands by keyboard) or by **macros**. A few macros are distributed with the examples
- **Simulation parameters** (geometry, visualization, primary particles, materials) can be **tuned without** the need to **recompile** the code